
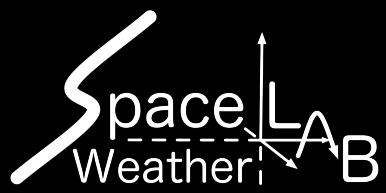



# Space Weather Services at NASA GSFC Space Weather Lab

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NASA Goddard Space Flight Center

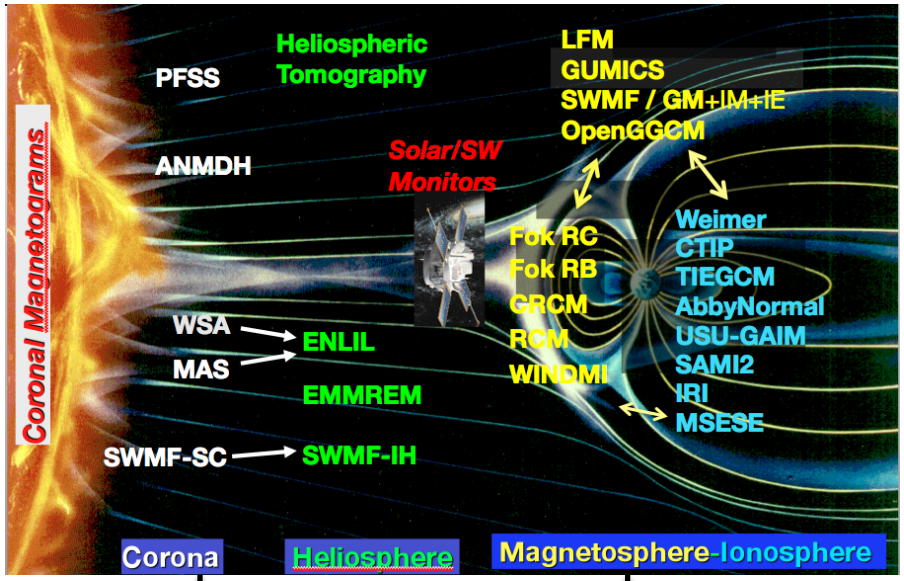
# Outline

- NASA/GSFC SWL assets: CCMC and ISWA
- Overview of GSFC Space Weather Services
- Forecasting example
- Summary

# Pillars of GSFC Space Weather Services

## CCMC

**C**ommunity **C**oordinated **M**odeling **C**enter
(in operations since 2000)

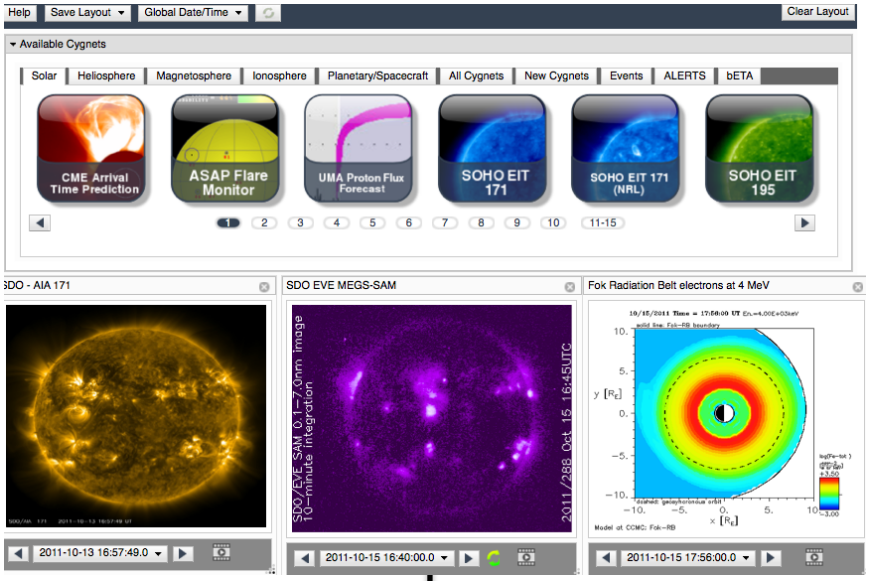



Facilitate Community Research

Address National SW Needs

## iSWA

**I**ntegrated **S**pace **W**eather **A**nalysis **S**ystem
(in operations since 2009)




Fetch latest SW information from diverse sources. Custom dissemination of data products and modeling results.

# Pillars of GSFC Space Weather Services

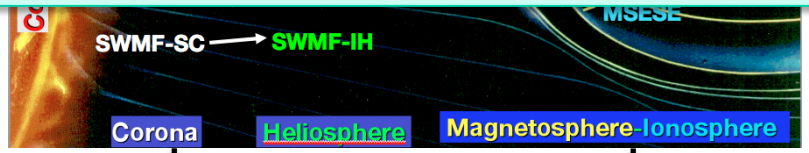
## CCMC

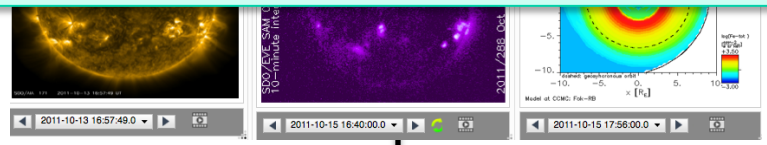
## iSWA


✓Knowledge (Research)
✓Models

✓Data/information
✓Dissemination

## Elements of Space Weather Forecasting




Facilitate Community Research

Address National SW Needs

Fetch latest SW information from diverse sources. Custom dissemination of data products and modeling results.

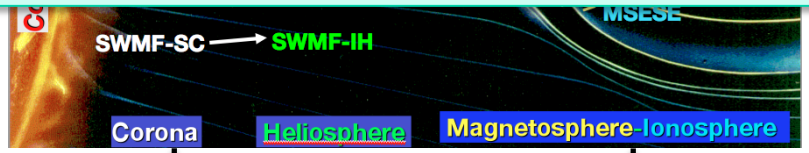
# Pillars of GSFC
# Space Weather Services

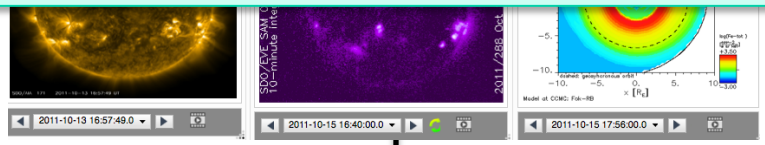
## CCMC

## iSWA

http://ccmc.gsfc.nasa.gov http://iswa.gsfc.nasa.gov

✓Web-based tools & services, available world-wide



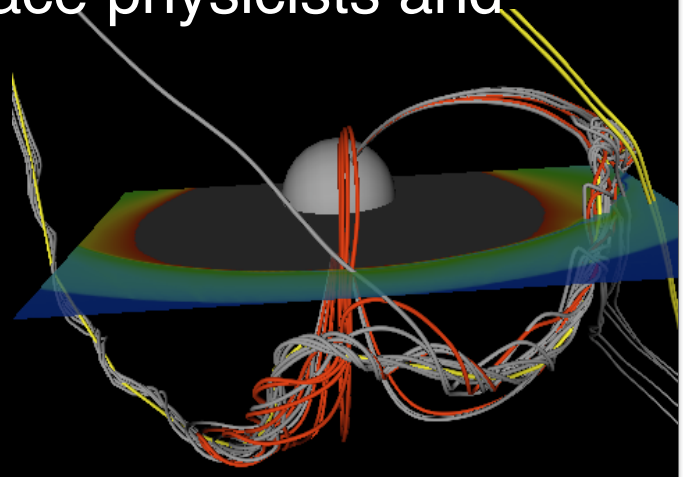
Facilitate Community Research

Address National SW Needs

Fetch latest SW information from diverse sources. Custom dissemination of data products and modeling results.

# CCMC Facts

- ✓ Supported by NASA and NSF
- ✓ Largest assembly of Space Weather models anywhere
- ✓ Automated run on request system
- ✓ Tailored science analysis interfaces, also used for SWx
- ✓ More than 5000 major model runs executed
- ✓ 24/7 RT run capability for more than 7 years
- ✓ Trusted relation with model owners
- ✓ Interdisciplinary team composed of space physicists and computer scientists.
- ✓ Unique experience



# CCMC: Model Testing and Evaluation

CCMC tests and evaluates modes

- as an unbiased agent
- through event studies, and through real-time calculations

CCMC leads and supports community-wide metrics challenges.

- Ground magnetic perturbations – dB/dt, Dst index, Auroral oval boundaries, .. (GEM)
- Ionosphere parameters (TEC, ..) (CEDAR)
- CMEs, CIRs arrival times (SHINE )

CCMC supports SWPC geospace operational model selection (physical quantities of interest: dB/dt).

# iSWA Facts:
# One-stop shop for state-of-the-art

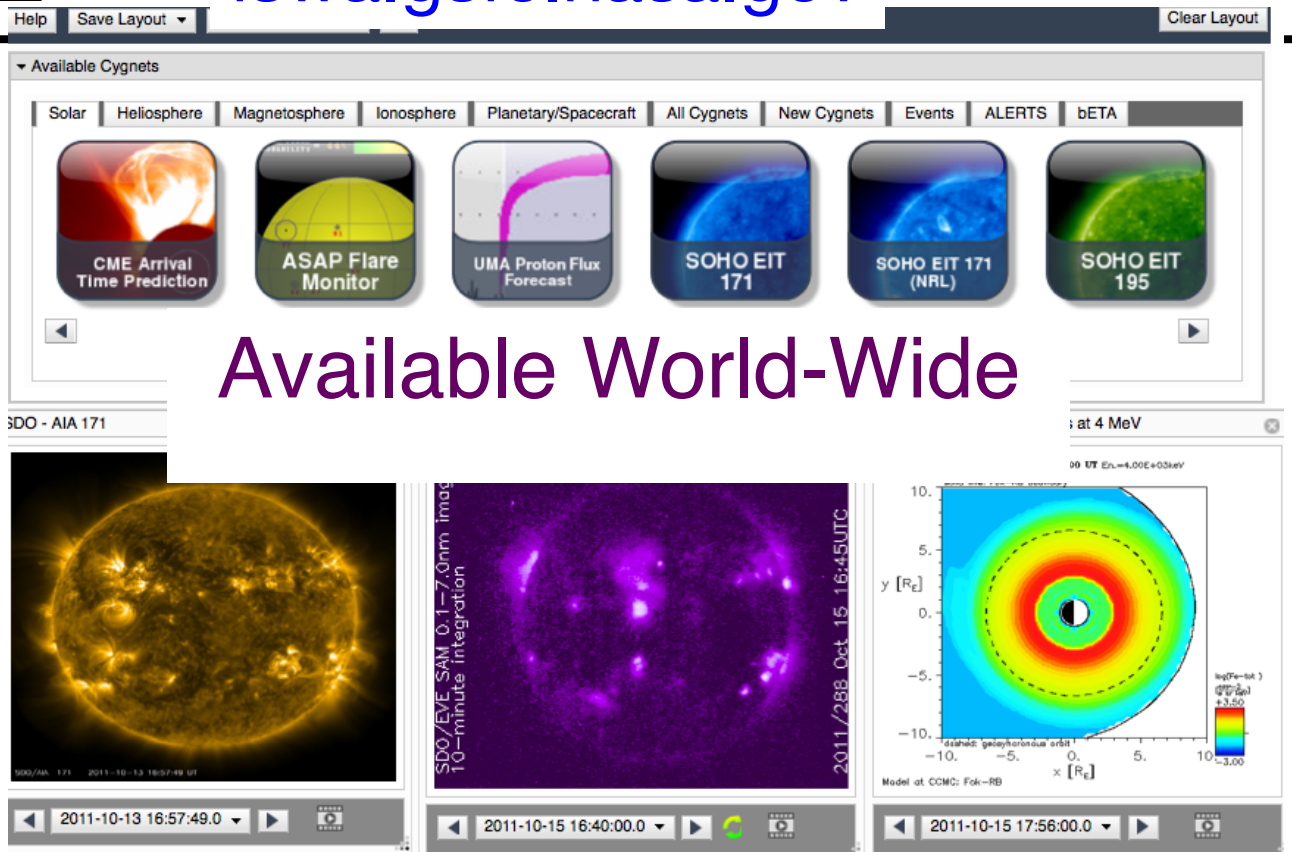

## Innovative Collection & Dissemination of SWx Information

User-configurable web-based system for analyzing space weather.

Flexible to adapt to changing environment.

**~300 products** including modeling results and comprehensive sets of observational data.

# iSWA Facts:
# iswa.gsfc.nasa.gov




## Available World-Wide

Features include: Global date/time (go back in time for anomaly resolution), Movie-mode, Super-timeline (RT validation), Save layout

# Space Weather Laboratory

COMMUNITY
COORDINATED
MODELING
CENTER

**World-leading modeling Expertise**

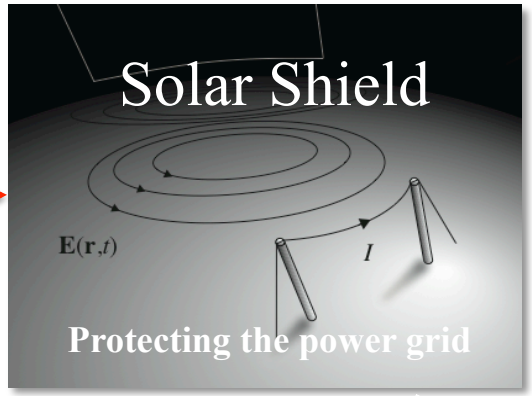
NASA, other, data streams

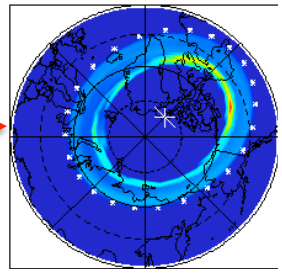
Space Weather Service

AFWA

JSC/SRAG (human flights)

**Partnering**

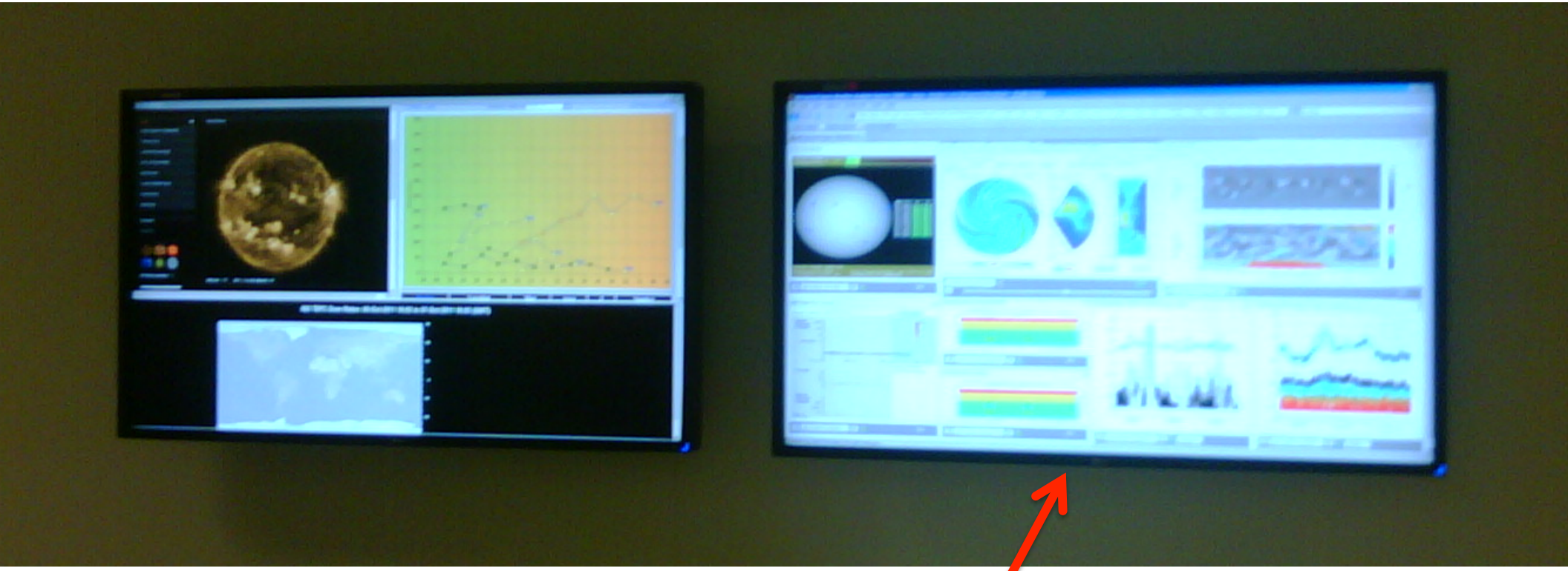



# GSFC SWx Services Status

- Staff of scientists/forecasters
- Partnering with AFWA and JSC/SRAG (human flights)
- Real-time SWx displays & products via iSWA.
- In-the-field SWx analysis capabilities
- Annual SWx and NASA robotic mission operator workshop
  - The third annual workshop: Sep 14 – 15, 2011



# SRAG monitor of iSWA products

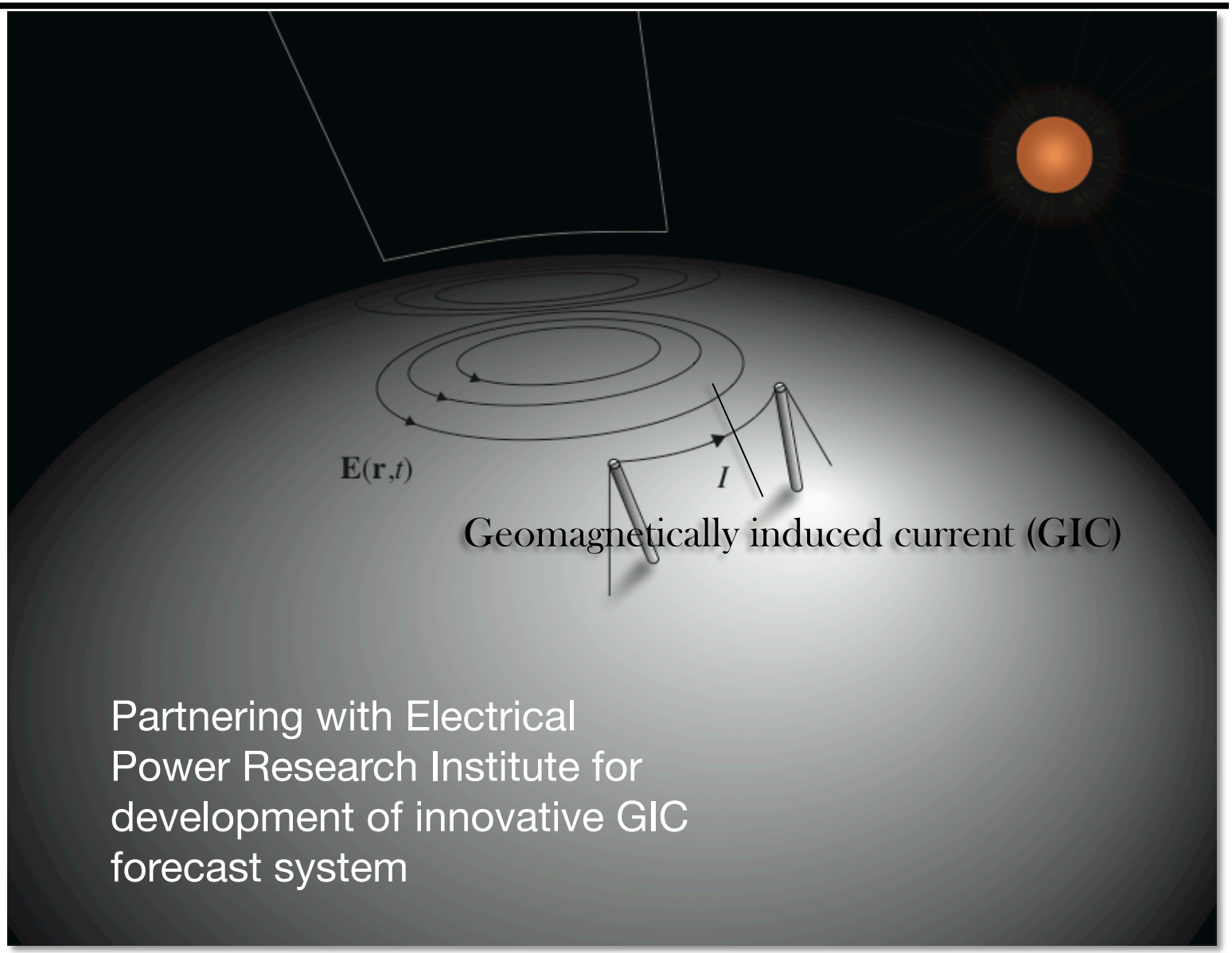


one iSWA layout for
SEP monitoring

# Comprehensive list of Space Weather Products

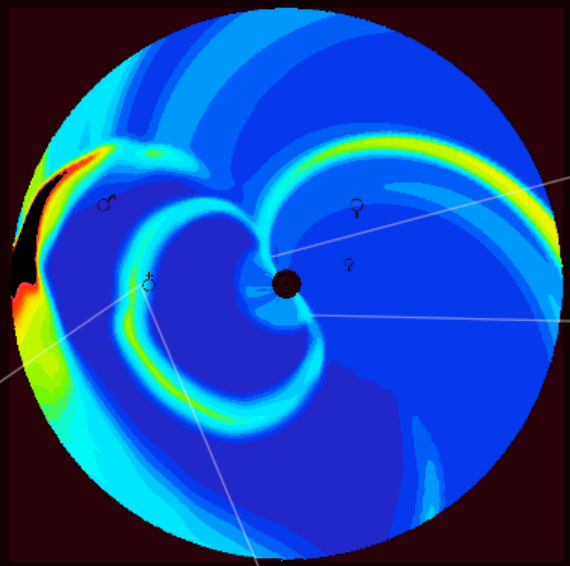
- CME forecasting and monitoring
- Flare forecasting and monitoring
- SEP forecasting and monitoring
- Heliospheric tomography model
- Global MHD models of Earth's magnetosphere
- Radiation belt modeling
- Ionospheric models in Joule heating, currents, density, temperature, etc. - relevant for assessing drag effects and GPS accuracy
- Many more

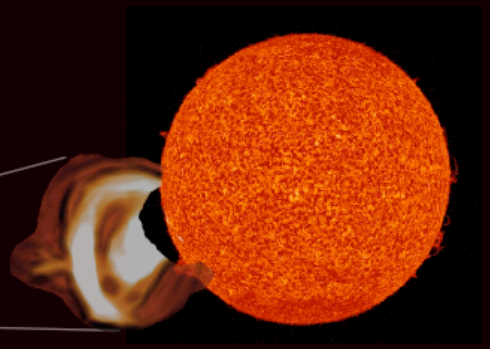
# Solar Shield:
# Protecting the Power Grid

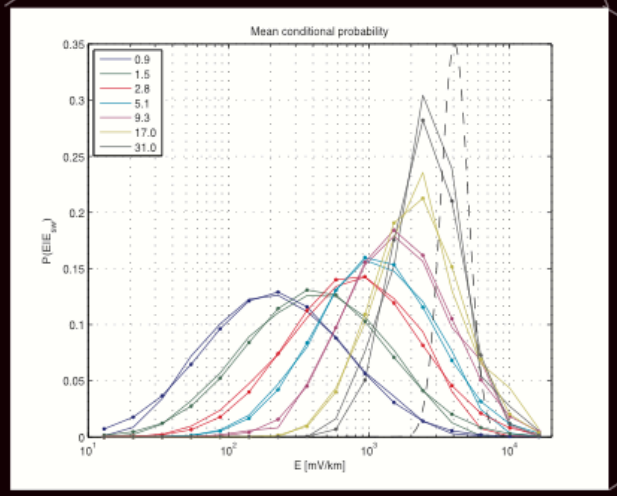



Partnering with Electrical Power Research Institute for development of innovative GIC forecast system

# Solar Shield: Level 1 forecast
# Lead-time: 1-2 days

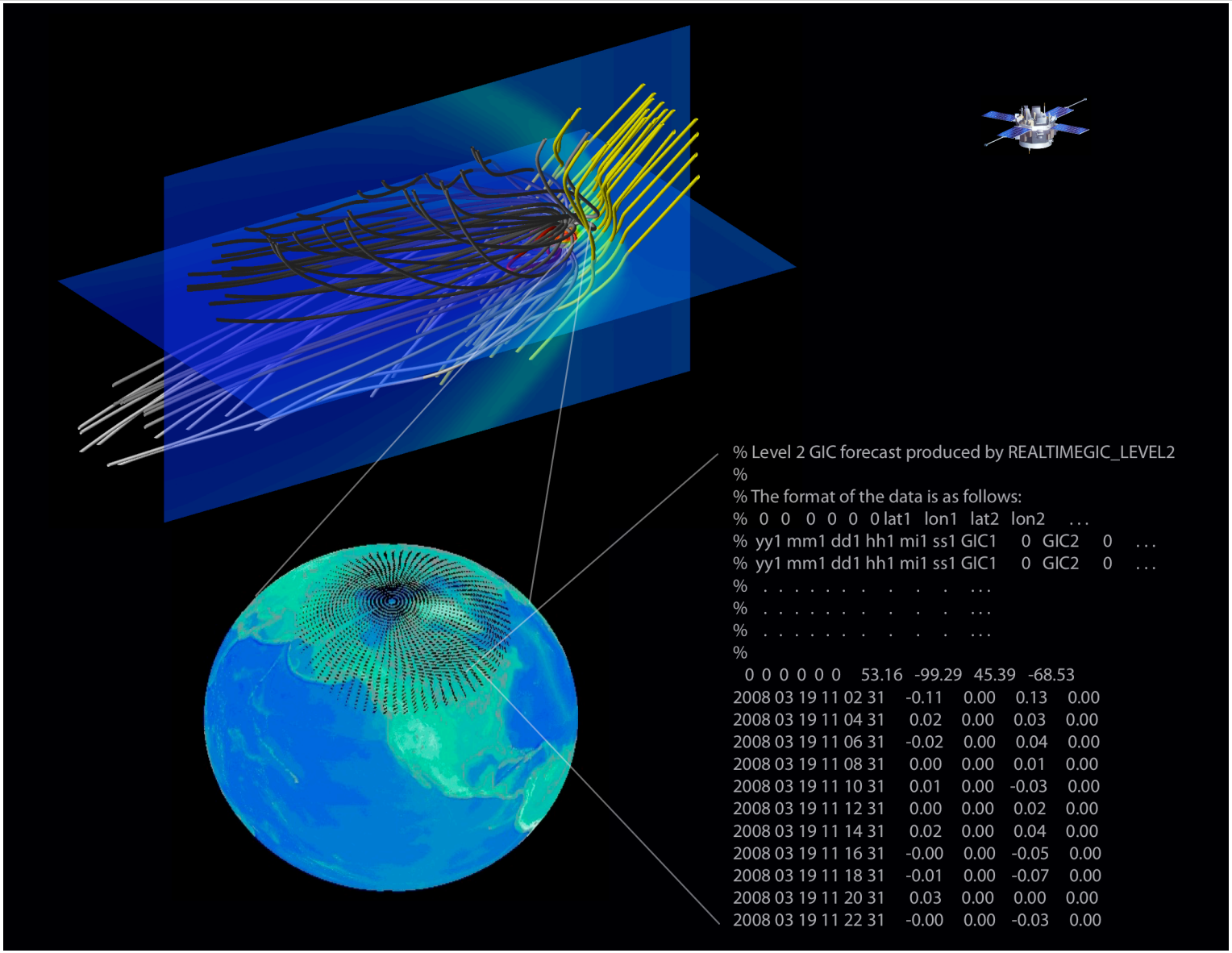






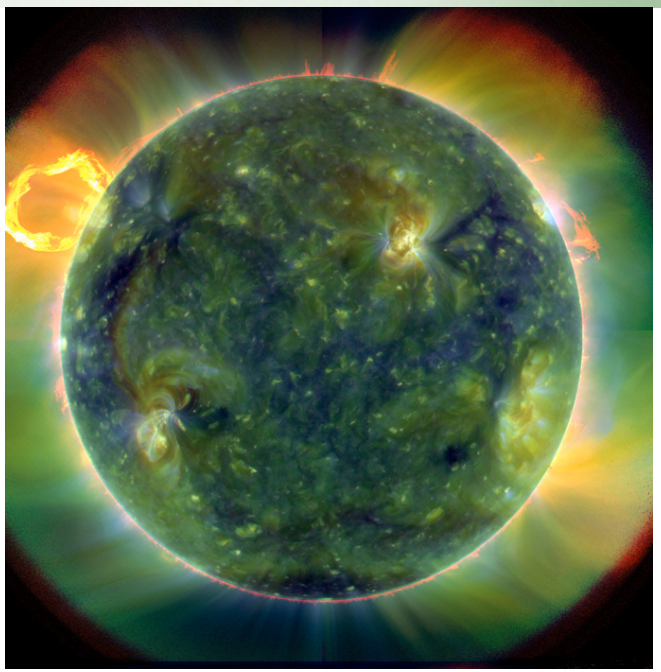

```
% Level 1 GIC forecast produced by REALTIMEGIC_LEVEL1
%
% The format of the data is as follows:
%  0  0  0  0  0 lat1    lon1     lat2    lon2     ...
% yy mm dd hh mi GIC1low GIC1high GIC2low GIC2high ...
%
  0  0  0  0  0    53.16  -99.29  45.39  -68.53
2006 12 14 14  6     76     15     153
```

# Solar Shield: Level 2 forecast
# Lead-time: 30-60 min



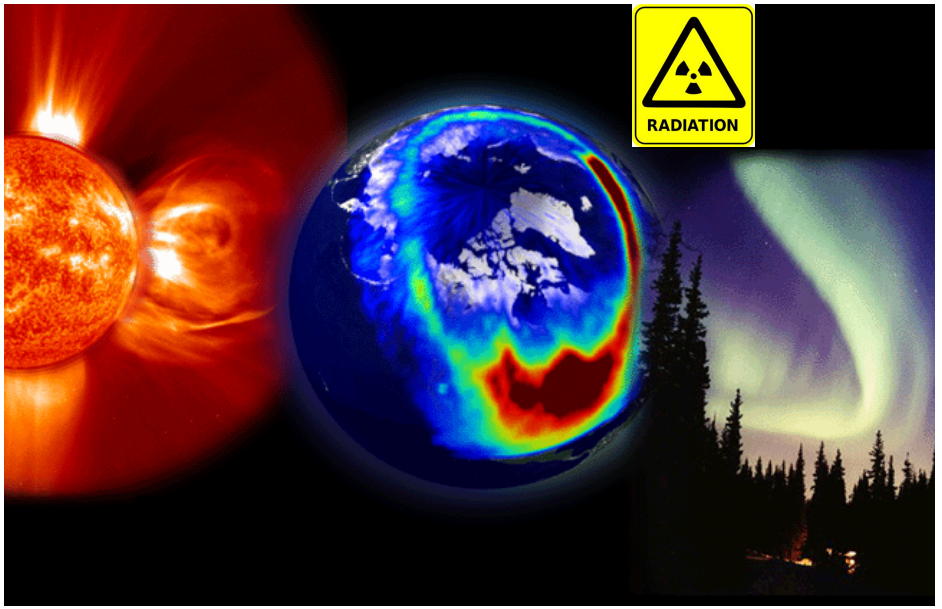
# Types of SWx Services

1. Providing assistance in spacecraft anomaly resolution by assessing whether space weather has any role in causing the observed anomaly/ anomalies.
2. Sending out weekly space weather reports/ summaries to NASA mission operators, NASA officials and involved personnel.

# Types of SWx Services - continued

3. Sending out timely space weather alerts/ forecasts regarding adverse conditions throughout the solar system, such as significant CME events, elevated radiation levels, geomagnetic storms, etc.

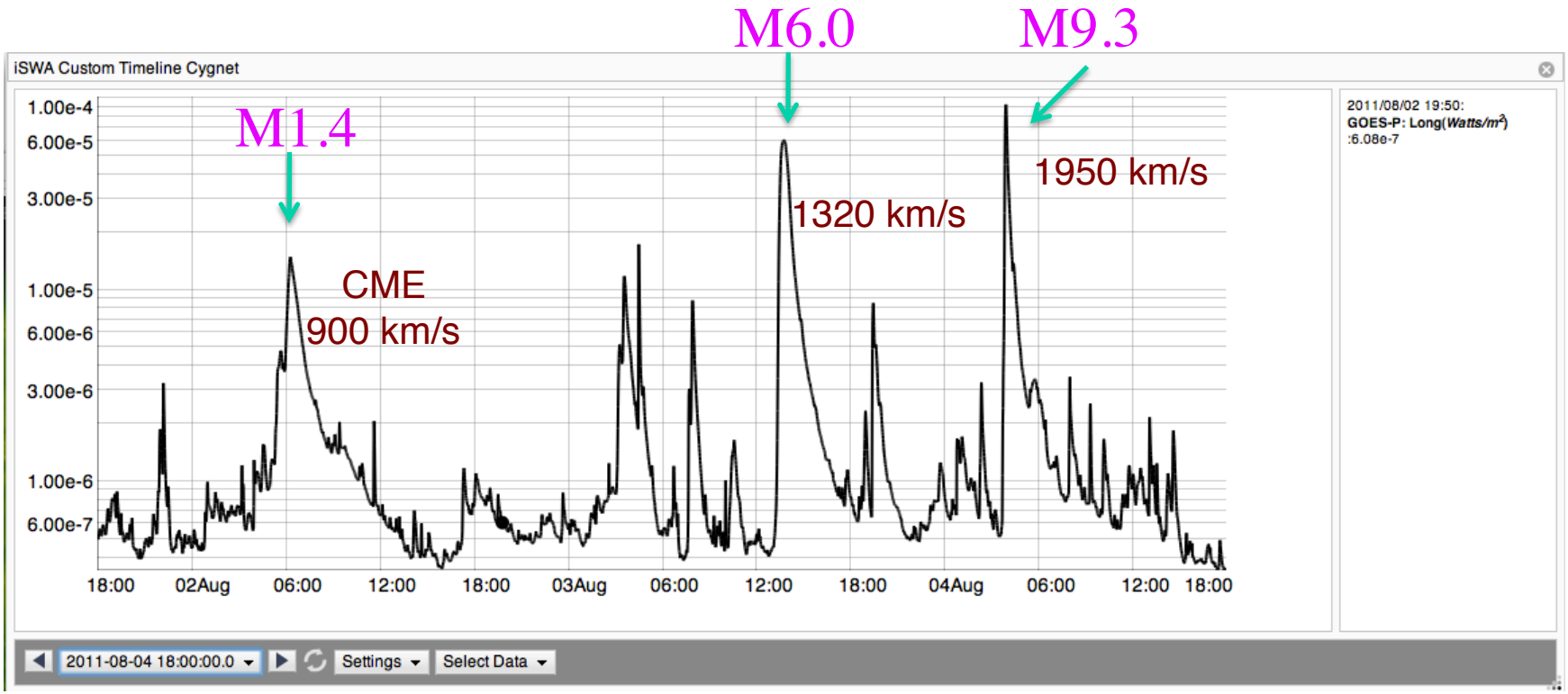



4. Providing general space weather support for NASA customers and the public.

# Forecasting Example: Aug 2-4, 2011 CME events

- iSWA allows tracking space weather events in the interplanetary space and forecast their impacts
- Sequence of recent major CME events Aug 2-4, 2011 that caused Kp = 8 geomagnetic storm on Aug 5, 2011.
- Synthesize available information to achieve most accurate forecast. Update forecast when new data become available.
- The sequence of events and forecasts demonstrated especially our current capacity to provide large lead-time space weather forecasts.

# Flares: x-ray

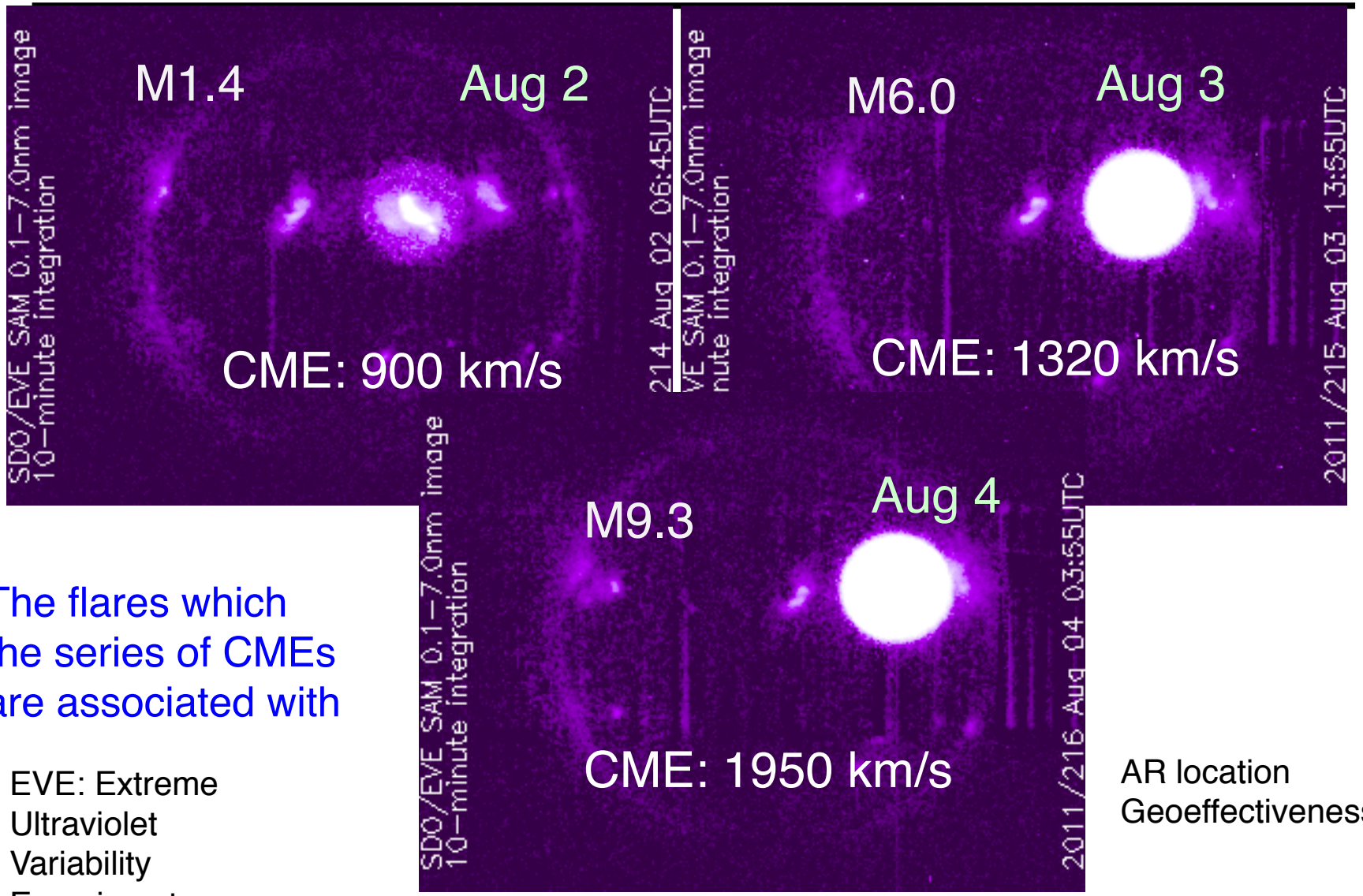



The flares which the series of CMEs are associated with: within a 48 hour period

Flare classification is based on GOES x-ray intensity (1-8 A)

# Flares: SDO EVE

## 2-D X-ray images

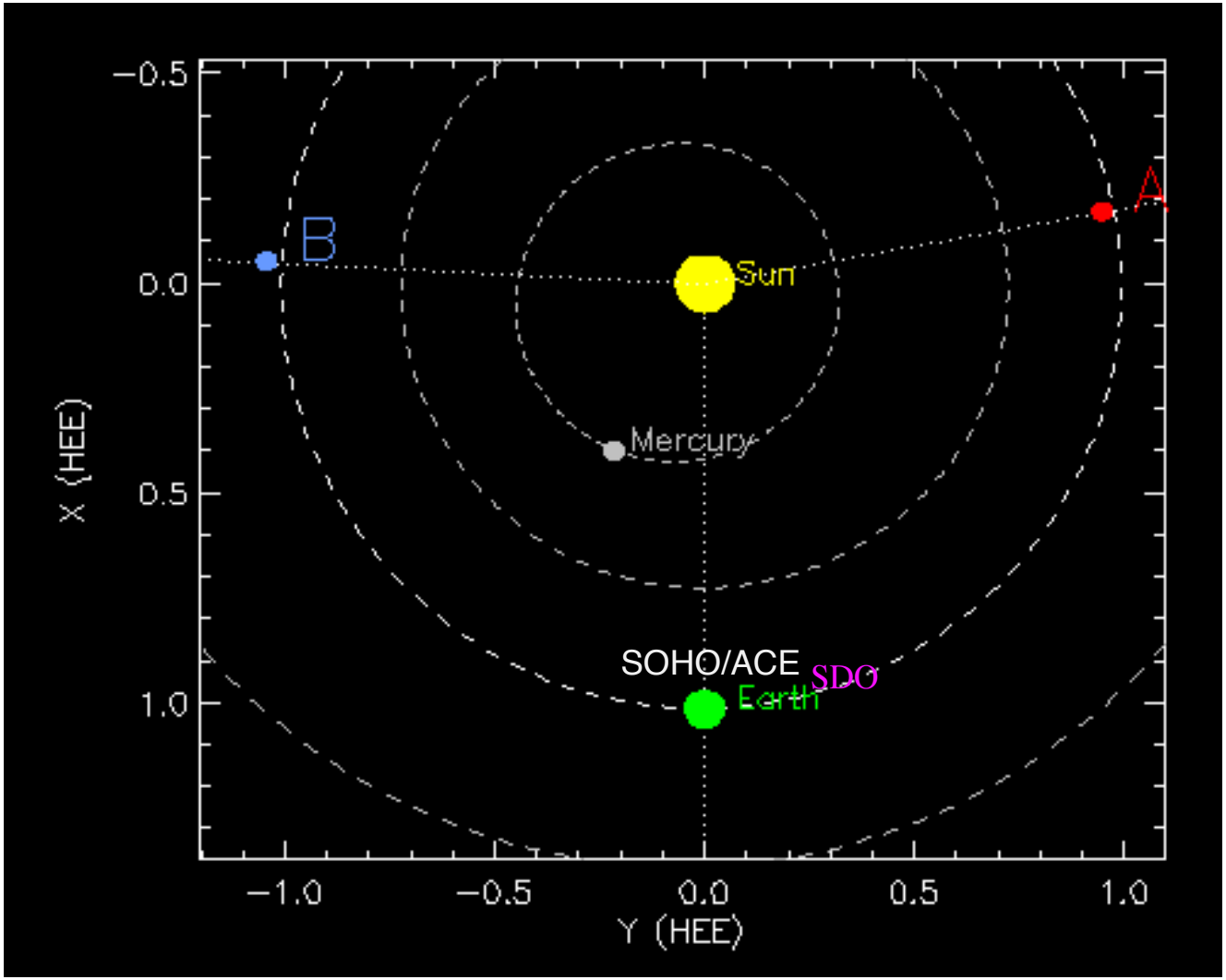



The flares which the series of CMEs are associated with

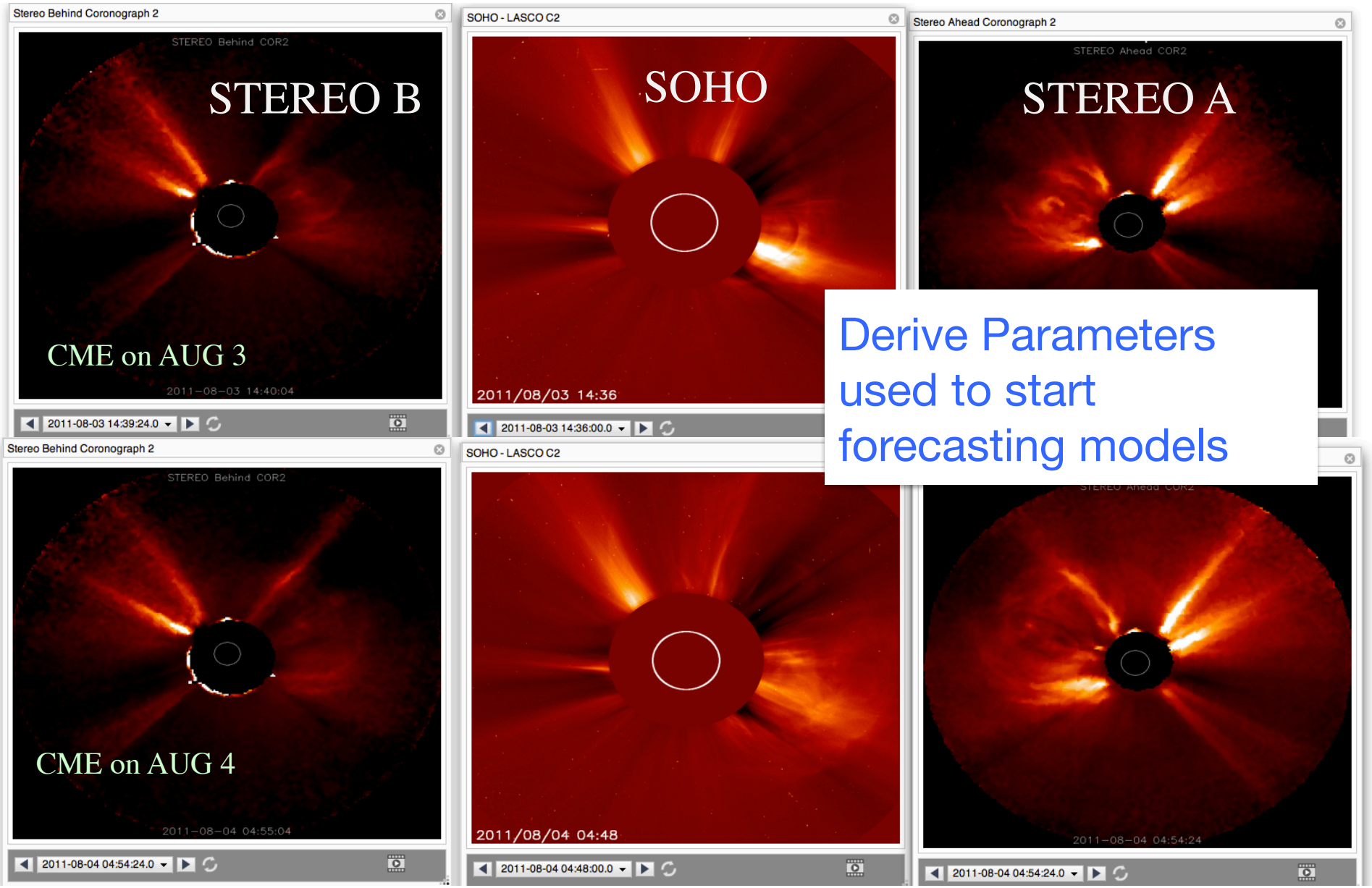
EVE: Extreme Ultraviolet Variability Experiment

AR location
Geoeffectiveness

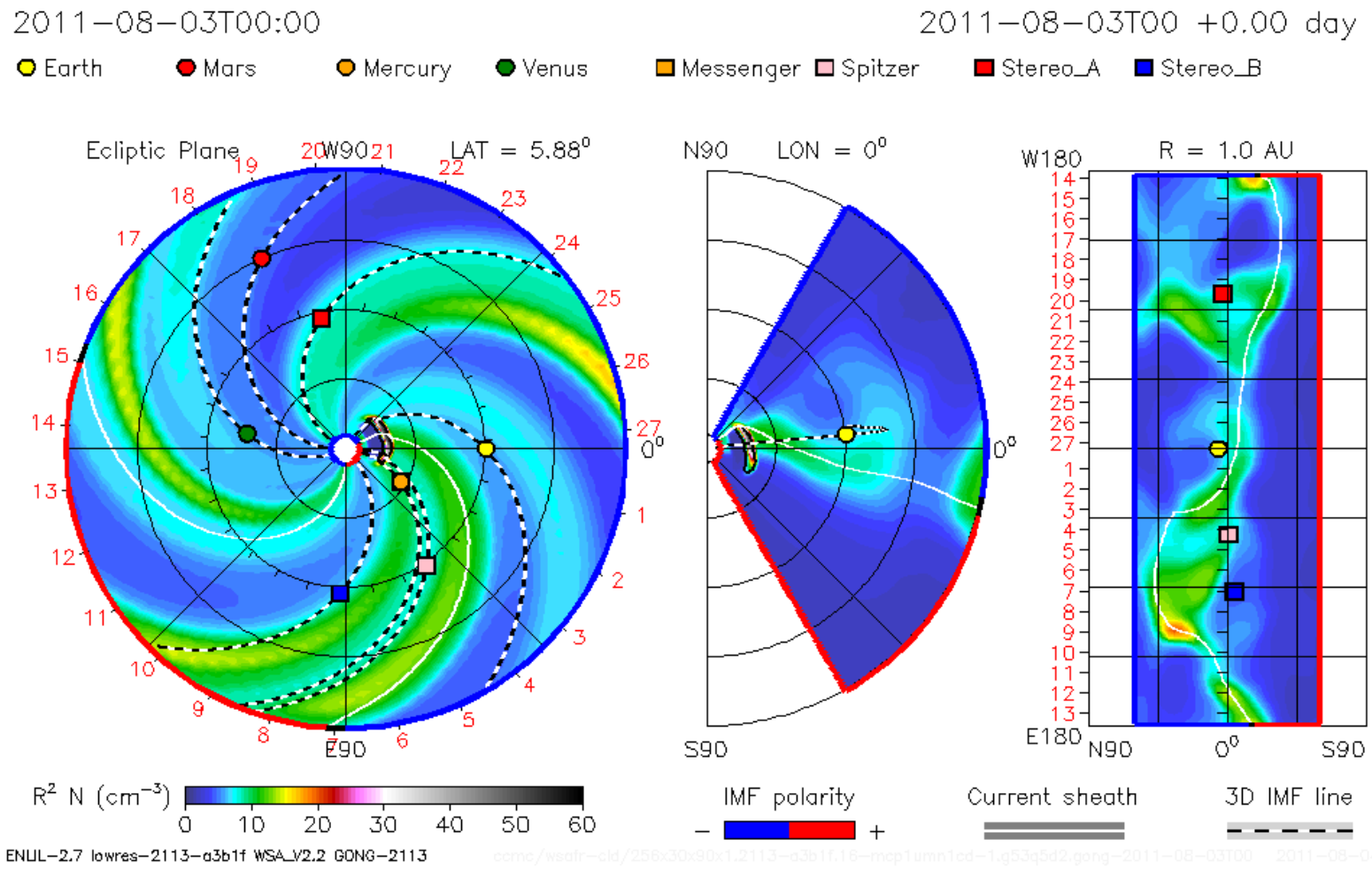
# Relative Position in HEE



# CME Detection: Coronagraph Images



# CME Forecasting




1-2 day lead-time forecasting

# Aug 2-4, 2011 events

## One of our CME alerts

## NASA Goddard Space Flight Center, Space Weather Laboratory ( SWL )
## Message Type: Space Weather Alert
##
## Message Issue Date: 2011-08-04T11:00:00Z
## Message ID: 20110804-AL-003

## Alert Summary:

A significant CME detected by STEREO-A COR2 / STEREO-B COR2 and SOHO LASCO C2/C3.

Start time of the event: 2011-08-04T04:10Z.

Estimated speed: ~ 1950 km/s.

Estimated opening half-angle: 60 deg.

Direction (lon./lat.): 40/14 in Heliocentric Earth Ecliptic coordinates.

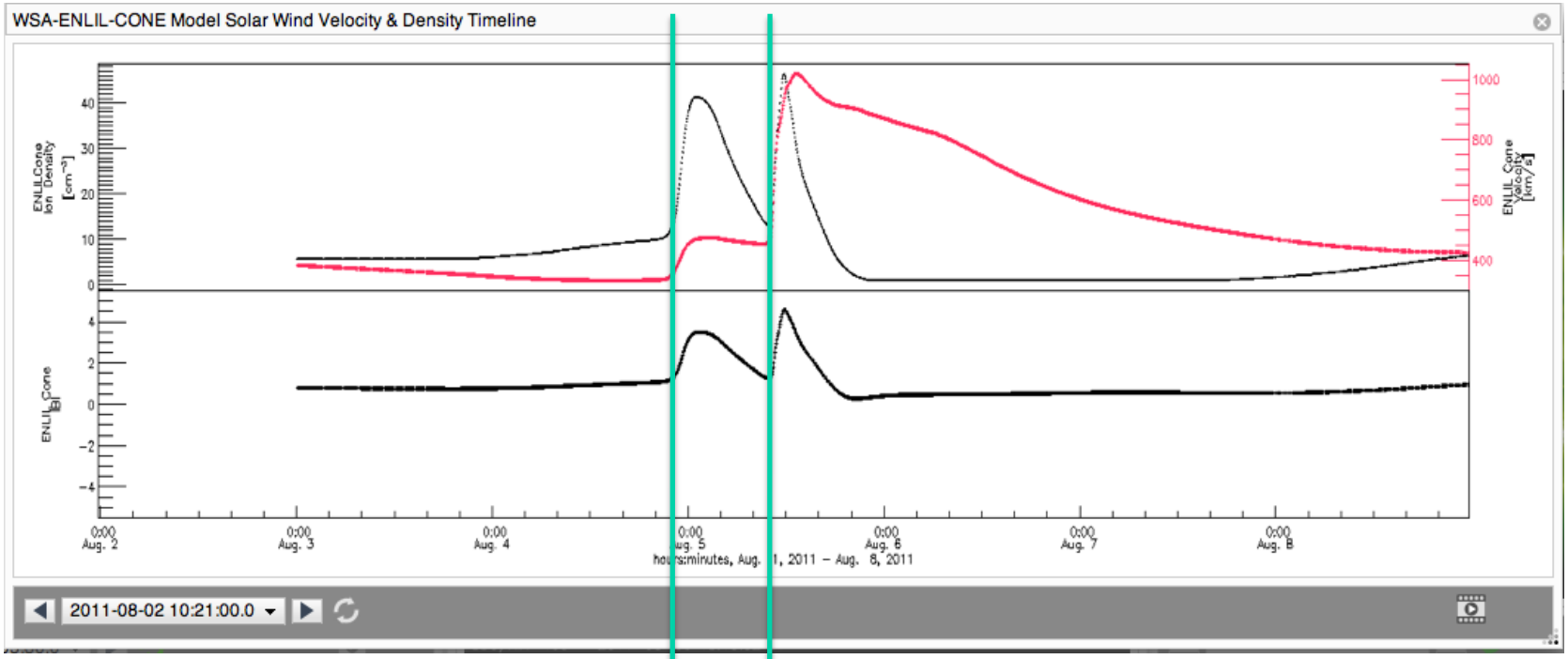
This CME is associated with the M9.3 class flare peaked at 2011-08-04T03:57Z from N16W38 (Region 1261) (see the alert 20110804-AL-001 earlier today).

Based on preliminary heliospheric modeling carried out at SWL, this CME is likely to interact with the CME occurred on 2011-08-03 and their combined effects will reach Earth at about 2011-08-05T13:55Z (plus minus 7 hours). The impact on Earth is likely to be major: the estimated maximum geomagnetic activity index level Kp is 7 (Kp ranges from 0 - 9). The flanks of the CME may impact STEREO A, Mars and Mercury/MESSENGER.

Further updates on the event will be provided when available.

Alert threshold: fast moving (approx. > 600 km/s) object in the imagery.

# Aug 2-4, 2011 CME events Prediction




Predicted initial impact
2011-08-04 21:30Z

Predicted major impact
2011-08-05 13:55Z

Observed initial impact
2011-08-04 21:00Z

Observed major impact
2011-08-05 17:25Z

Predicted max. Kp = 7

Observed max. Kp = 8

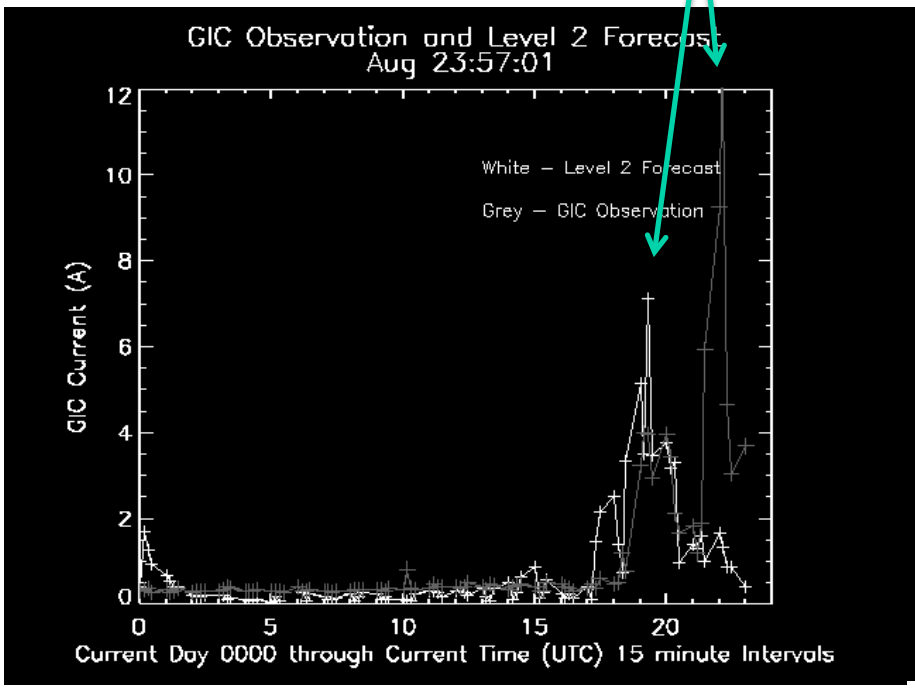
Predicted GIC range: 1-36 A

Observed max. GIC was 12 A

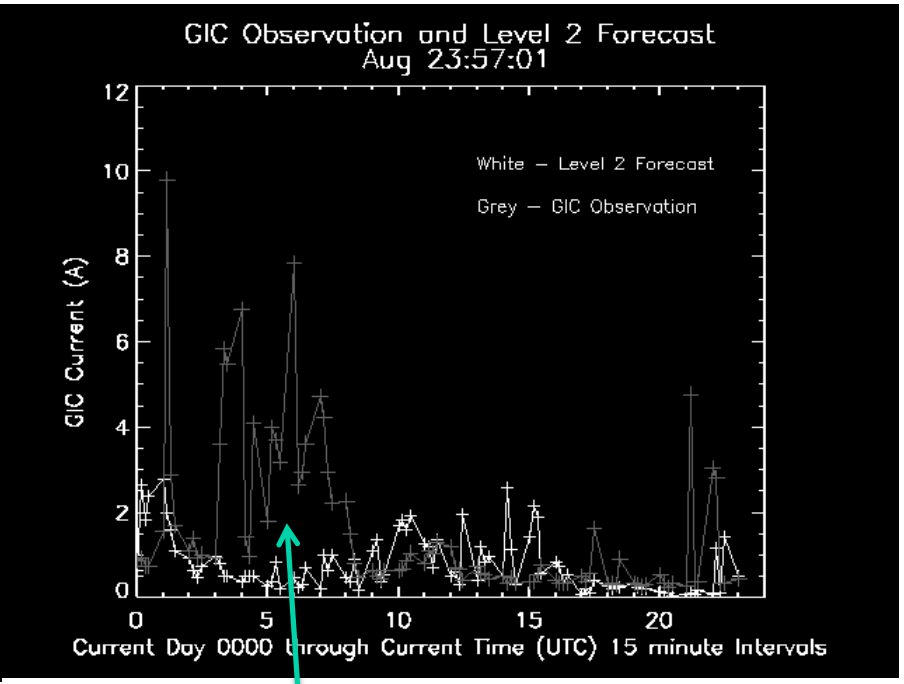
# Solar Shield – Level 2 forecast

Max. amplitudes captured fairly well

Aug 5, 2011




Aug 6, 2011




Beginning of the event was captured fairly well

Capturing the mid-storm evolution needs improvement

# Summary

GSFC SWx Services for NASA robotic missions is a successful example of R2O.

Represents a maximum leverage of latest scientific research results and over a decade modeling experience enabled by CCMC.

GSFC has developed a world-leading information collection and public dissemination system, which supports NASA missions and other interests, such as the electrical power grid

Partnering, e.g., with AFWA, NSF, DHS, EPRI, Europe, Korea, Russia, commercial sector… is very important

Space weather benefits substantially by exploiting the proximity to scientific research.

There is tremendous additional potential to address national space weather needs in innovative, collaborative, and cost-effective ways.